FIG.1

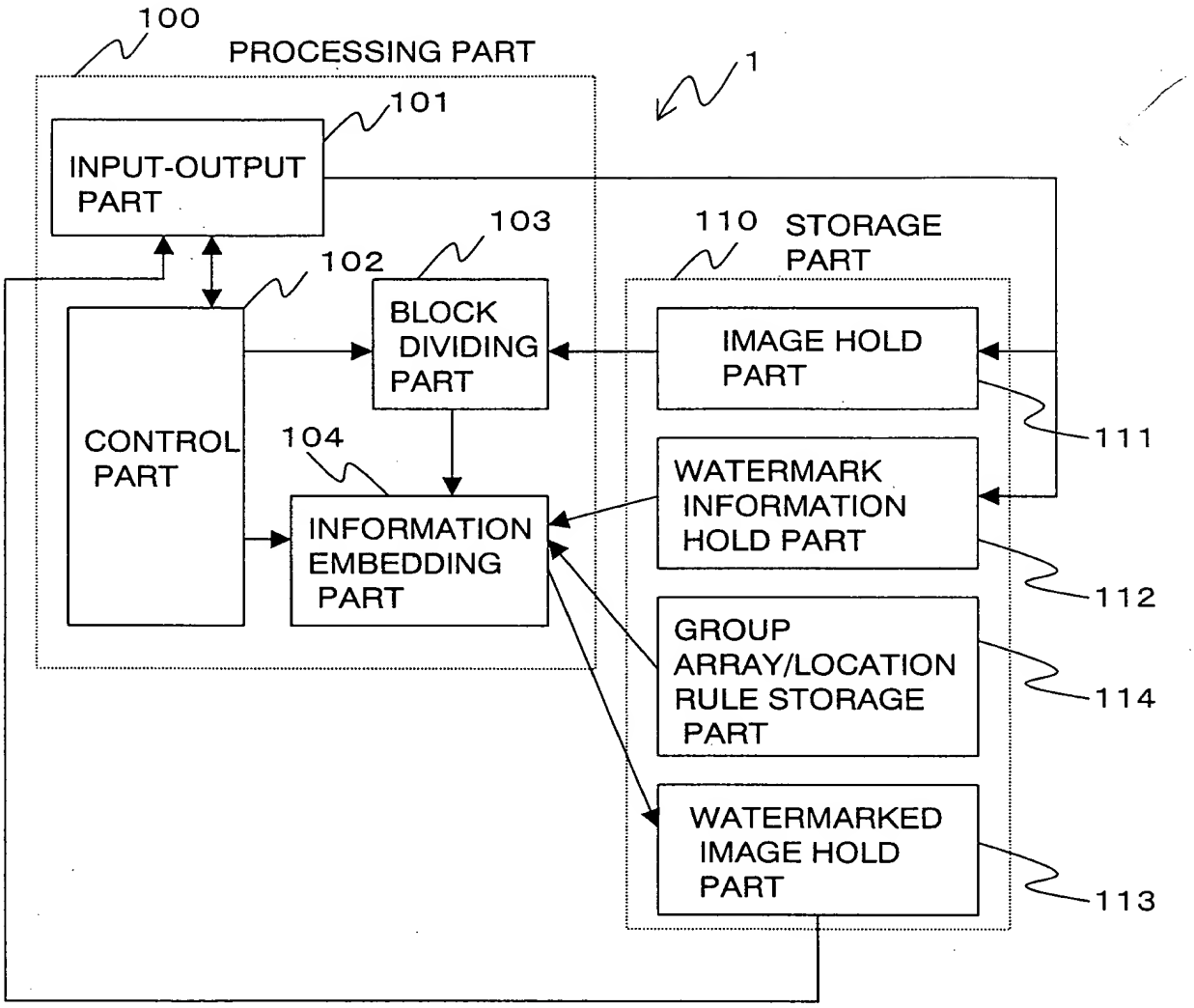

100
PROCESSING PART
1
101
INPUT-OUTPUT PART
103
110 STORAGE PART
102
BLOCK DIVIDING PART
IMAGE HOLD PART
CONTROL PART
104
WATERMARK INFORMATION HOLD PART
111
INFORMATION EMBEDDING PART
112
GROUP ARRAY/LOCATION RULE STORAGE PART
114
WATERMARKED IMAGE HOLD PART
113

FIG.2

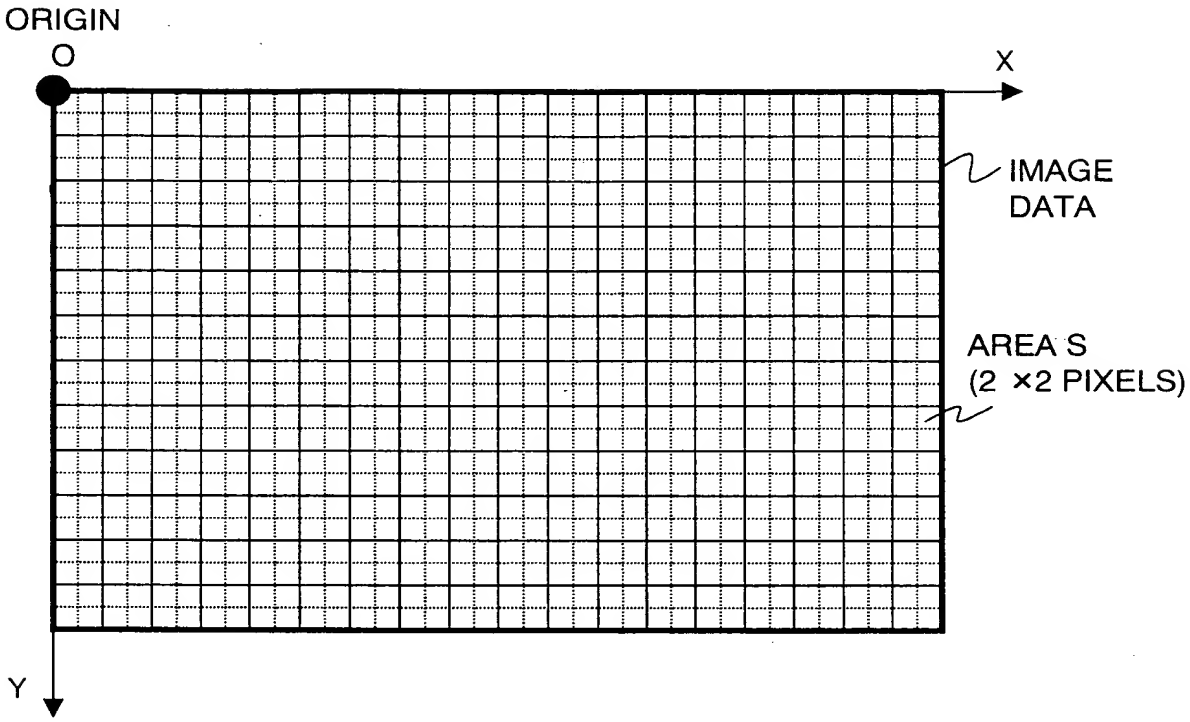


FIG.3

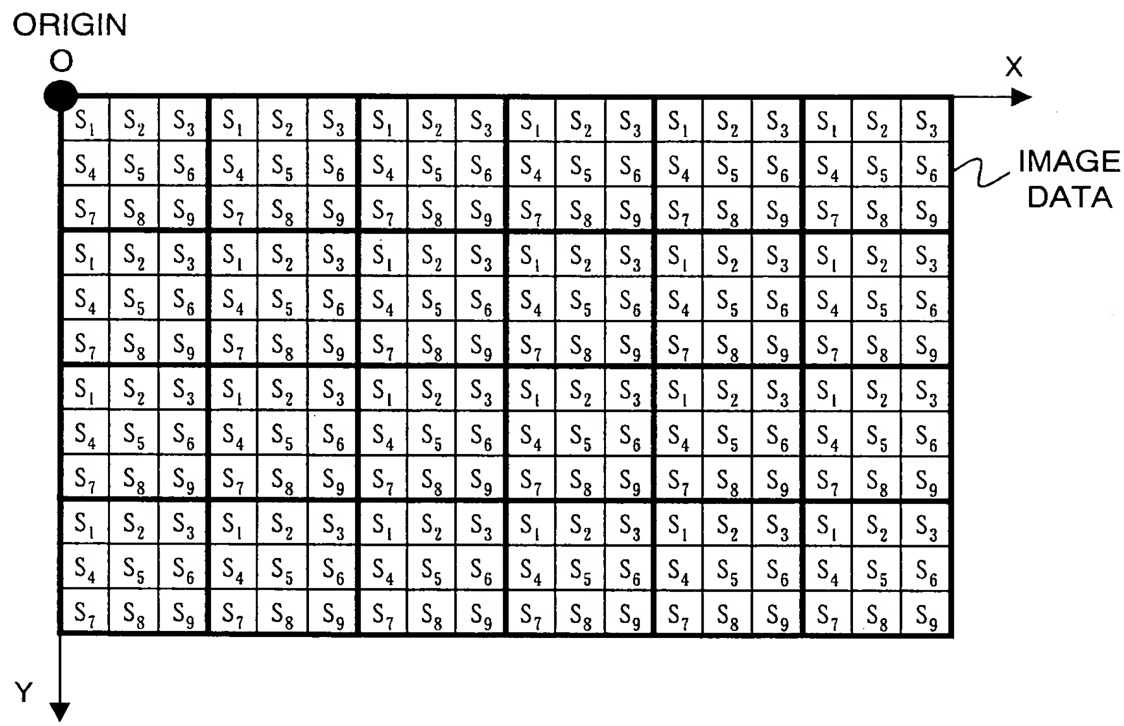
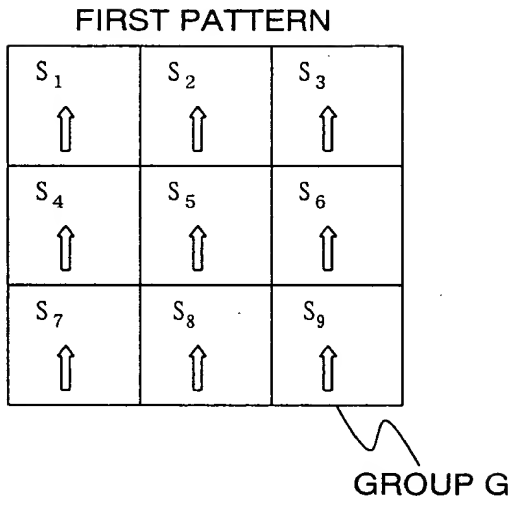
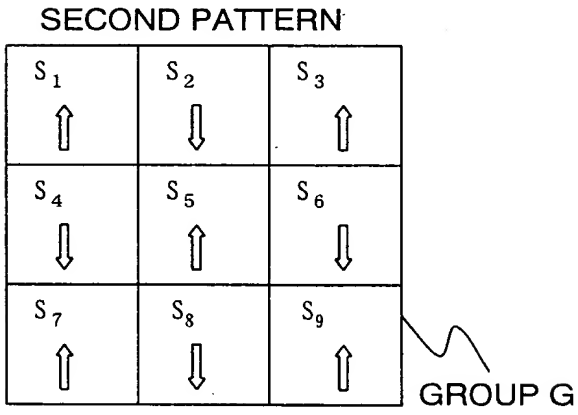

ORIGIN
O
X
Y
IMAGE DATA
S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3
S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6
S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9
S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3
S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6
S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9
S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3
S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6
S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9
S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3 S_1 S_2 S_3
S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6 S_4 S_5 S_6
S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9 S_7 S_8 S_9

FIG.4





⇧ FOR A BIT 1, BRIGHTNESS IS INCREASED.
FOR A BIT 0, BRIGHTNESS IS DECREASED

⇩ FOR A BIT 1, BRIGHTNESS IS DECREASED.
FOR A BIT 0, BRIGHTNESS IS INCREASED.

FIG.5

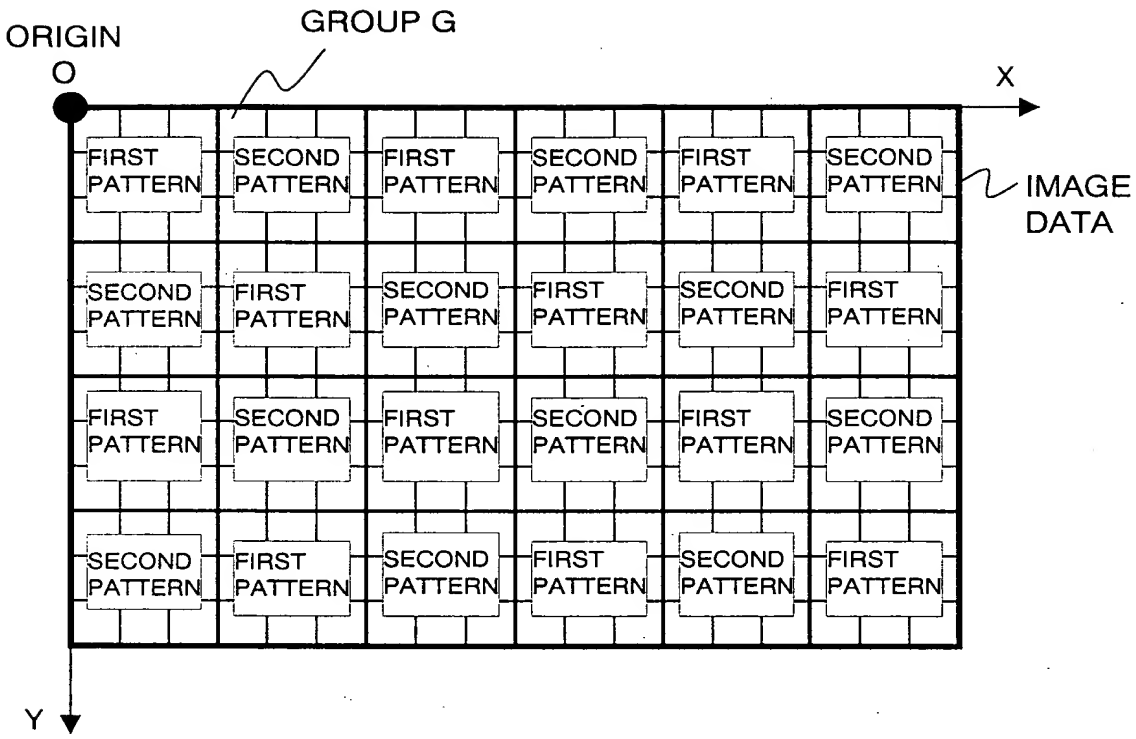


FIG.6

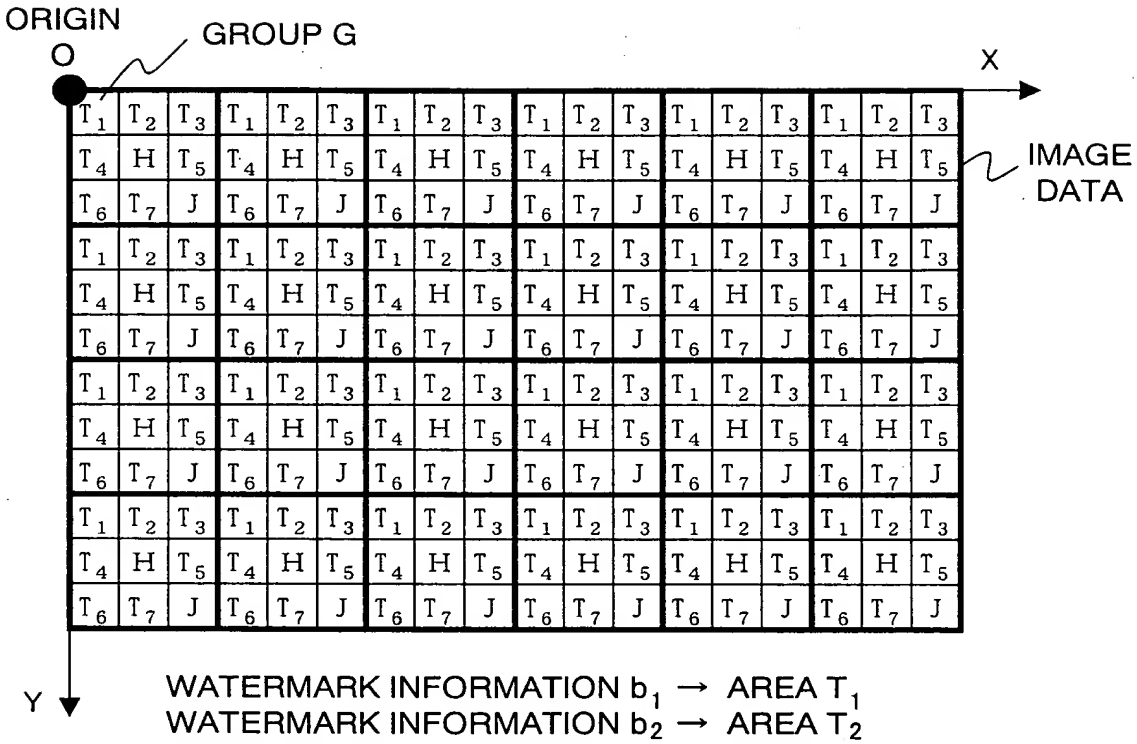

ORIGIN
O
GROUP G
X
Y
IMAGE DATA
WATERMARK INFORMATION b_1 → AREA T_1
WATERMARK INFORMATION b_2 → AREA T_2
WATERMARK INFORMATION b_3 → AREA T_3
WATERMARK INFORMATION b_4 → AREA T_4
WATERMARK INFORMATION b_5 → AREA T_5
WATERMARK INFORMATION b_6 → AREA T_6
WATERMARK INFORMATION b_7 → AREA T_7
EMBEDDING INFORMATION p → AREA J
NO INFORMATION → AREA H

FIG.7

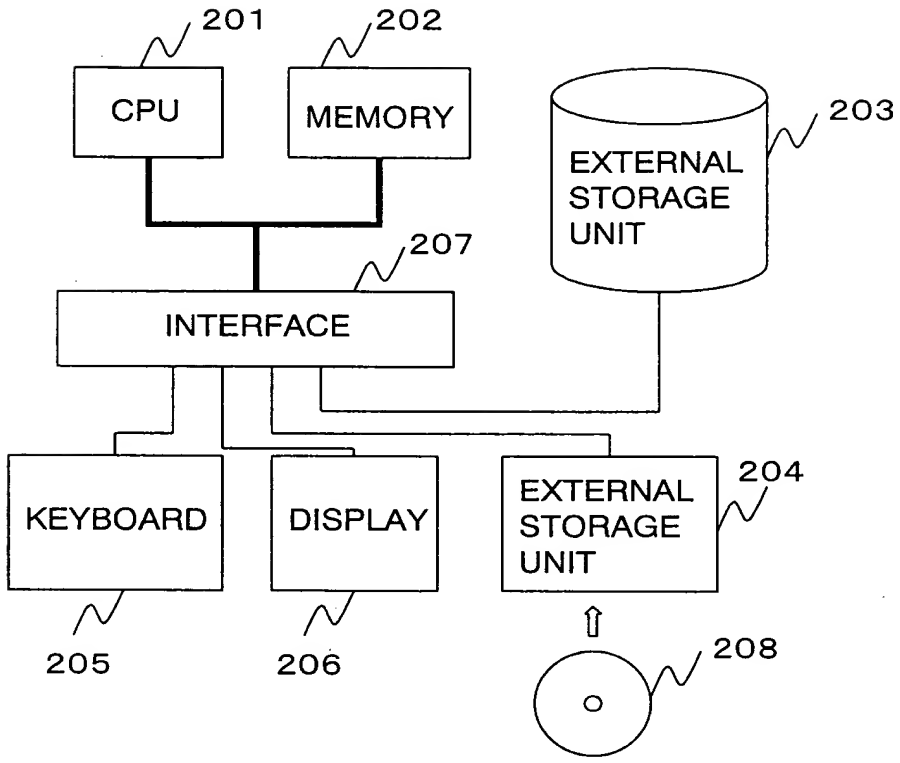

201
202
CPU
MEMORY
203
EXTERNAL STORAGE UNIT
207
INTERFACE
KEYBOARD
DISPLAY
204
EXTERNAL STORAGE UNIT
205
206
208

FIG.8

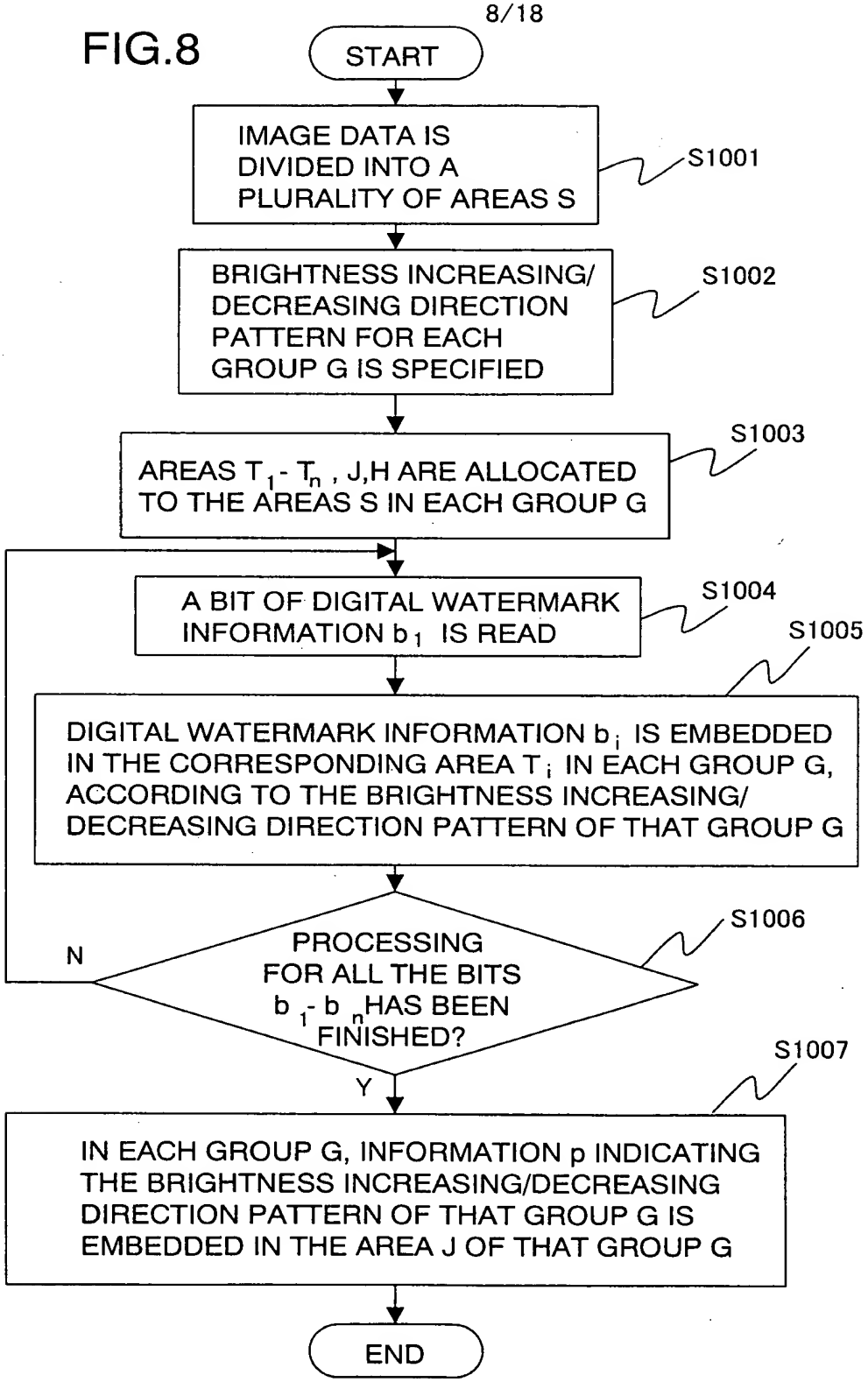

START
IMAGE DATA IS DIVIDED INTO A PLURALITY OF AREAS S
S1001
BRIGHTNESS INCREASING/ DECREASING DIRECTION PATTERN FOR EACH GROUP G IS SPECIFIED
S1002
AREAS T_1- T_n , J,H ARE ALLOCATED TO THE AREAS S IN EACH GROUP G
S1003
A BIT OF DIGITAL WATERMARK INFORMATION b_1 IS READ
S1004
DIGITAL WATERMARK INFORMATION b_i IS EMBEDDED IN THE CORRESPONDING AREA T_i IN EACH GROUP G, ACCORDING TO THE BRIGHTNESS INCREASING/ DECREASING DIRECTION PATTERN OF THAT GROUP G
S1005
PROCESSING FOR ALL THE BITS b_1- b_n HAS BEEN FINISHED?
S1006
N
Y
IN EACH GROUP G, INFORMATION p INDICATING THE BRIGHTNESS INCREASING/DECREASING DIRECTION PATTERN OF THAT GROUP G IS EMBEDDED IN THE AREA J OF THAT GROUP G
S1007
END

FIG.9

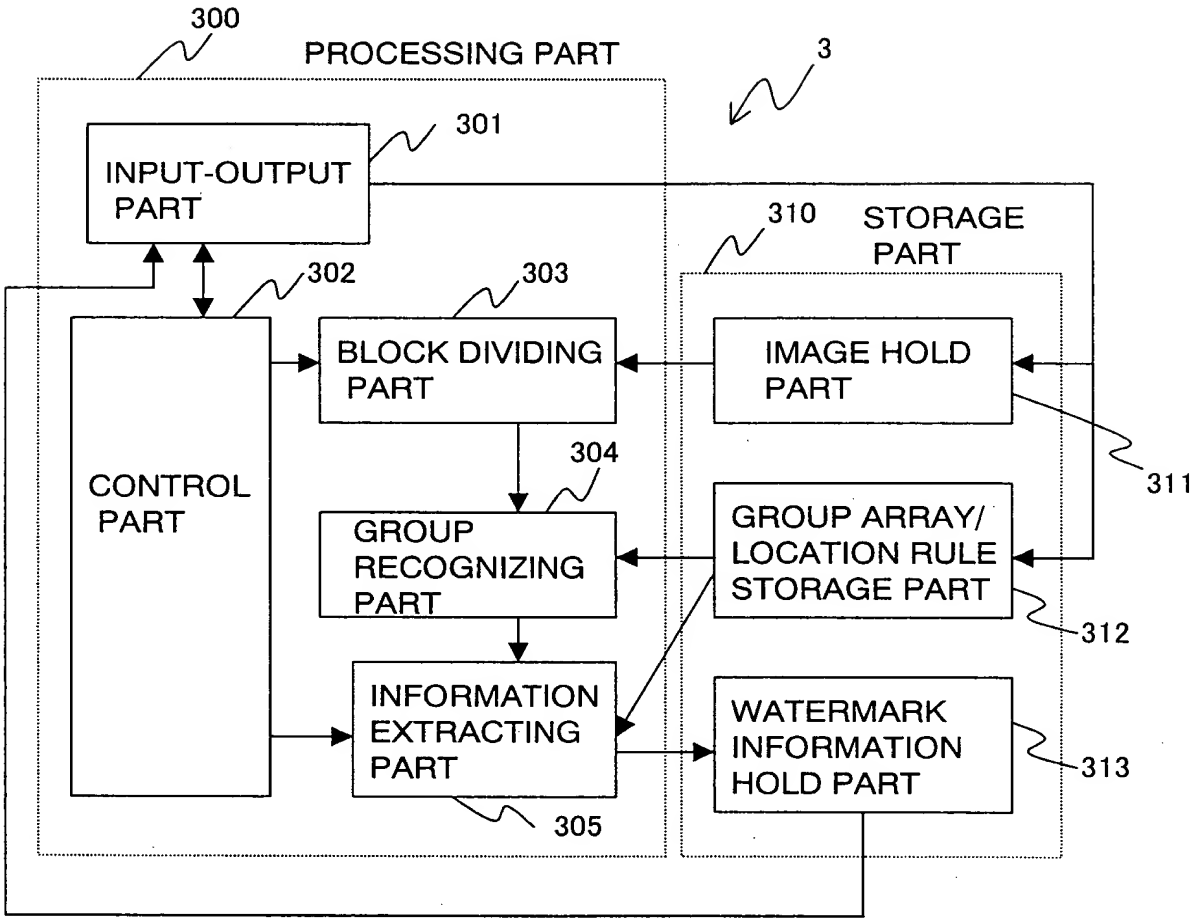

300
PROCESSING PART
3
301
INPUT-OUTPUT PART
310
STORAGE PART
302
303
CONTROL PART
BLOCK DIVIDING PART
IMAGE HOLD PART
311
304
GROUP RECOGNIZING PART
GROUP ARRAY/ LOCATION RULE STORAGE PART
312
INFORMATION EXTRACTING PART
WATERMARK INFORMATION HOLD PART
313
305

FIG.10

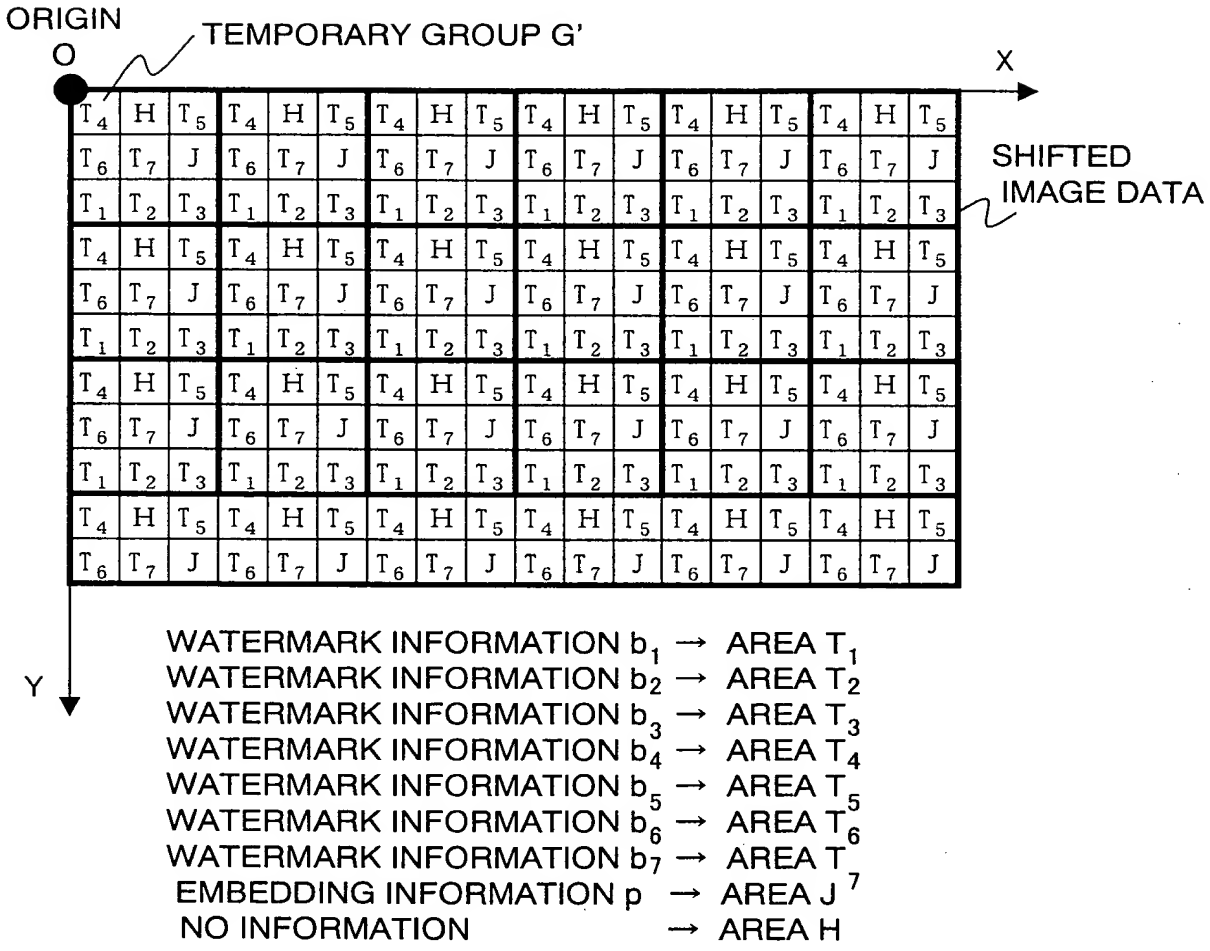

ORIGIN
O
TEMPORARY GROUP G'
X
Y
SHIFTED
IMAGE DATA
WATERMARK INFORMATION b_1 → AREA T_1
WATERMARK INFORMATION b_2 → AREA T_2
WATERMARK INFORMATION b_3 → AREA T_3
WATERMARK INFORMATION b_4 → AREA T_4
WATERMARK INFORMATION b_5 → AREA T_5
WATERMARK INFORMATION b_6 → AREA T_6
WATERMARK INFORMATION b_7 → AREA T_7
EMBEDDING INFORMATION p → AREA J
NO INFORMATION → AREA H

FIG.11

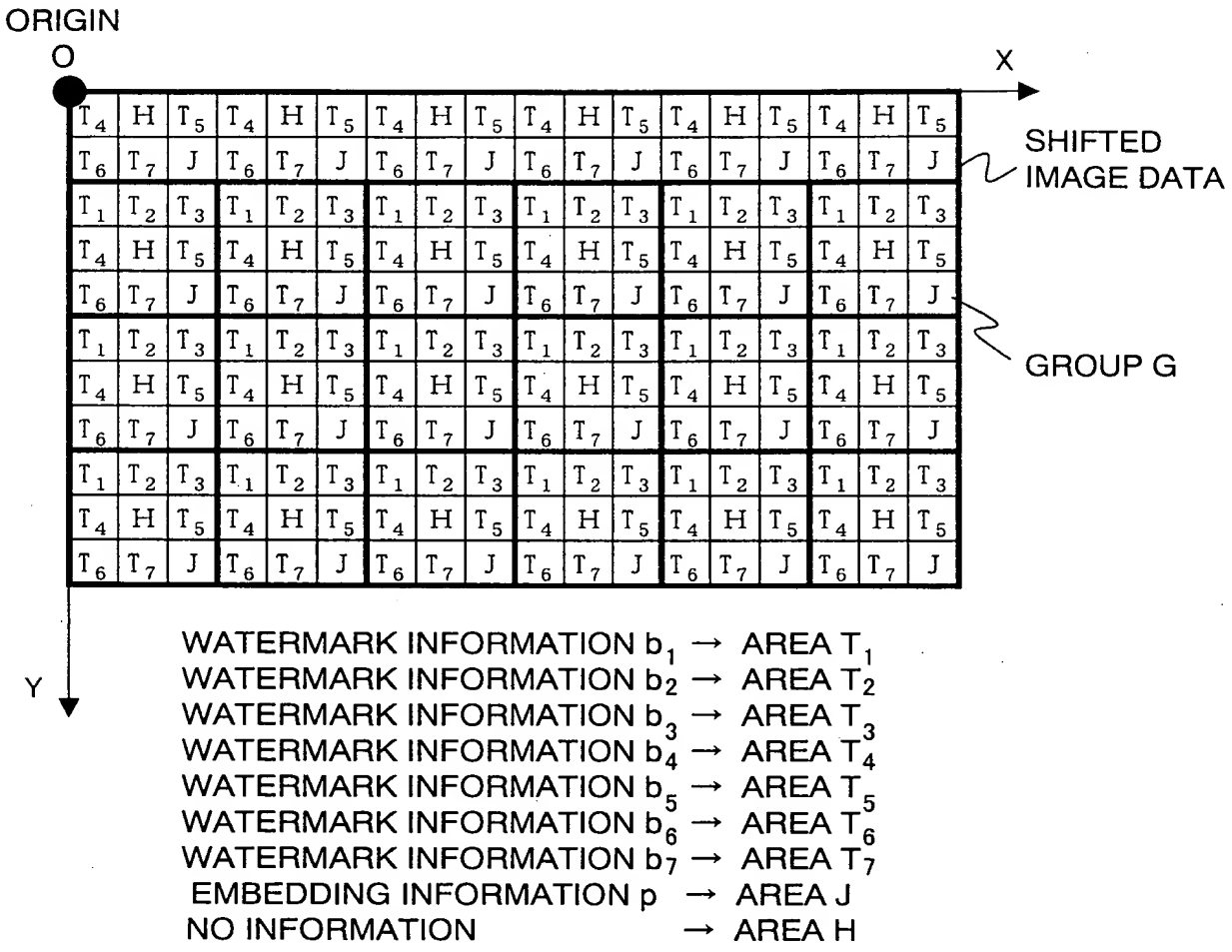

ORIGIN
O
X
Y
SHIFTED IMAGE DATA
GROUP G
WATERMARK INFORMATION b_1 → AREA T_1
WATERMARK INFORMATION b_2 → AREA T_2
WATERMARK INFORMATION b_3 → AREA T_3
WATERMARK INFORMATION b_4 → AREA T_4
WATERMARK INFORMATION b_5 → AREA T_5
WATERMARK INFORMATION b_6 → AREA T_6
WATERMARK INFORMATION b_7 → AREA T_7
EMBEDDING INFORMATION p → AREA J
NO INFORMATION → AREA H

FIG.12

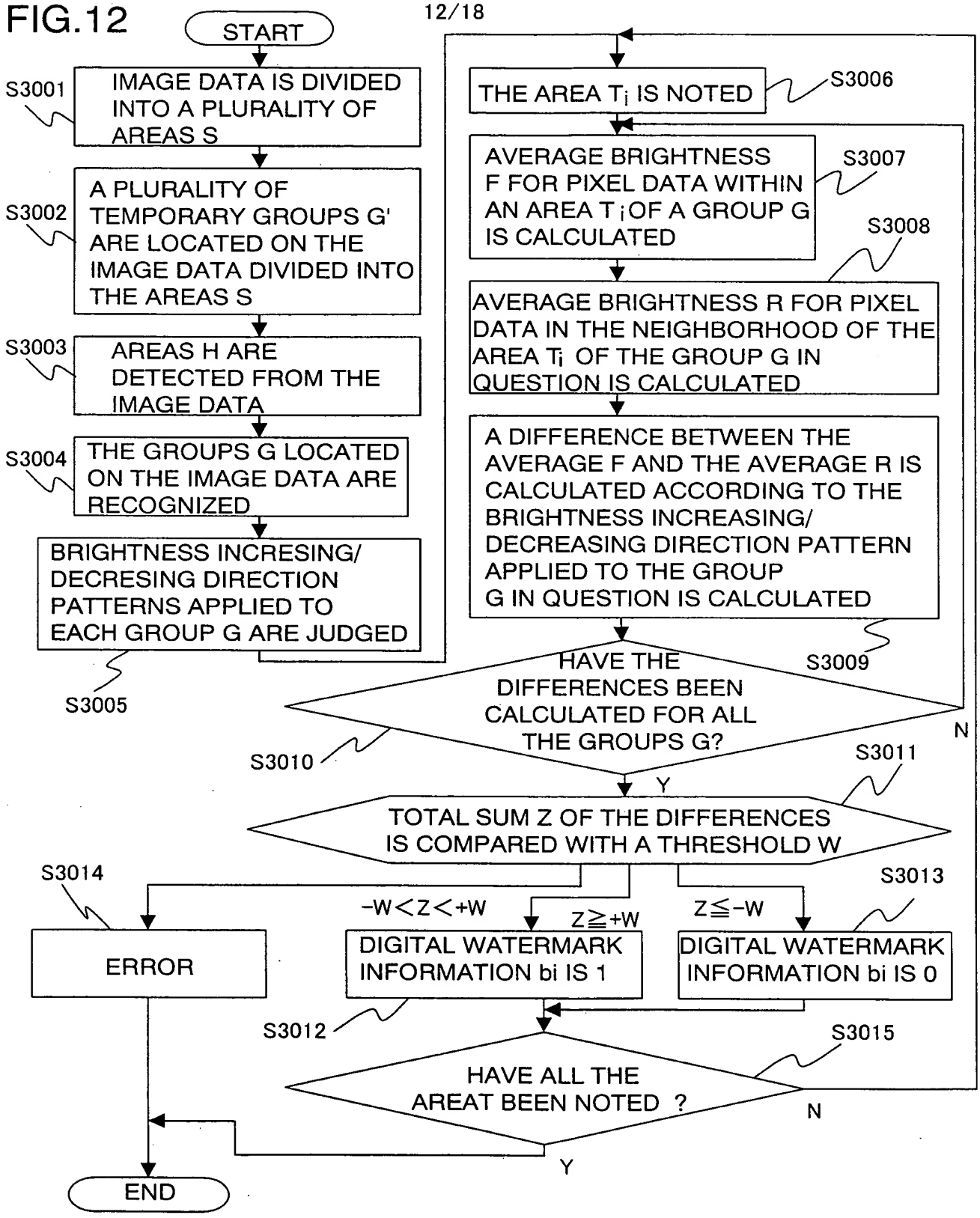

START
S3001
IMAGE DATA IS DIVIDED INTO A PLURALITY OF AREAS S
S3002
A PLURALITY OF TEMPORARY GROUPS G' ARE LOCATED ON THE IMAGE DATA DIVIDED INTO THE AREAS S
S3003
AREAS H ARE DETECTED FROM THE IMAGE DATA
S3004
THE GROUPS G LOCATED ON THE IMAGE DATA ARE RECOGNIZED
BRIGHTNESS INCRESING/ DECRESING DIRECTION PATTERNS APPLIED TO EACH GROUP G ARE JUDGED
S3005
THE AREA Ti IS NOTED
S3006
AVERAGE BRIGHTNESS F FOR PIXEL DATA WITHIN AN AREA Ti OF A GROUP G IS CALCULATED
S3007
AVERAGE BRIGHTNESS R FOR PIXEL DATA IN THE NEIGHBORHOOD OF THE AREA Ti OF THE GROUP G IN QUESTION IS CALCULATED
S3008
A DIFFERENCE BETWEEN THE AVERAGE F AND THE AVERAGE R IS CALCULATED ACCORDING TO THE BRIGHTNESS INCREASING/ DECREASING DIRECTION PATTERN APPLIED TO THE GROUP G IN QUESTION IS CALCULATED
S3009
HAVE THE DIFFERENCES BEEN CALCULATED FOR ALL THE GROUPS G?
S3010
N
Y
S3011
TOTAL SUM Z OF THE DIFFERENCES IS COMPARED WITH A THRESHOLD W
S3014
-W<Z<+W
Z≧+W
Z≦-W
S3013
ERROR
DIGITAL WATERMARK INFORMATION bi IS 1
DIGITAL WATERMARK INFORMATION bi IS 0
S3012
S3015
HAVE ALL THE AREAT BEEN NOTED ?
N
Y
END

FIG.13A

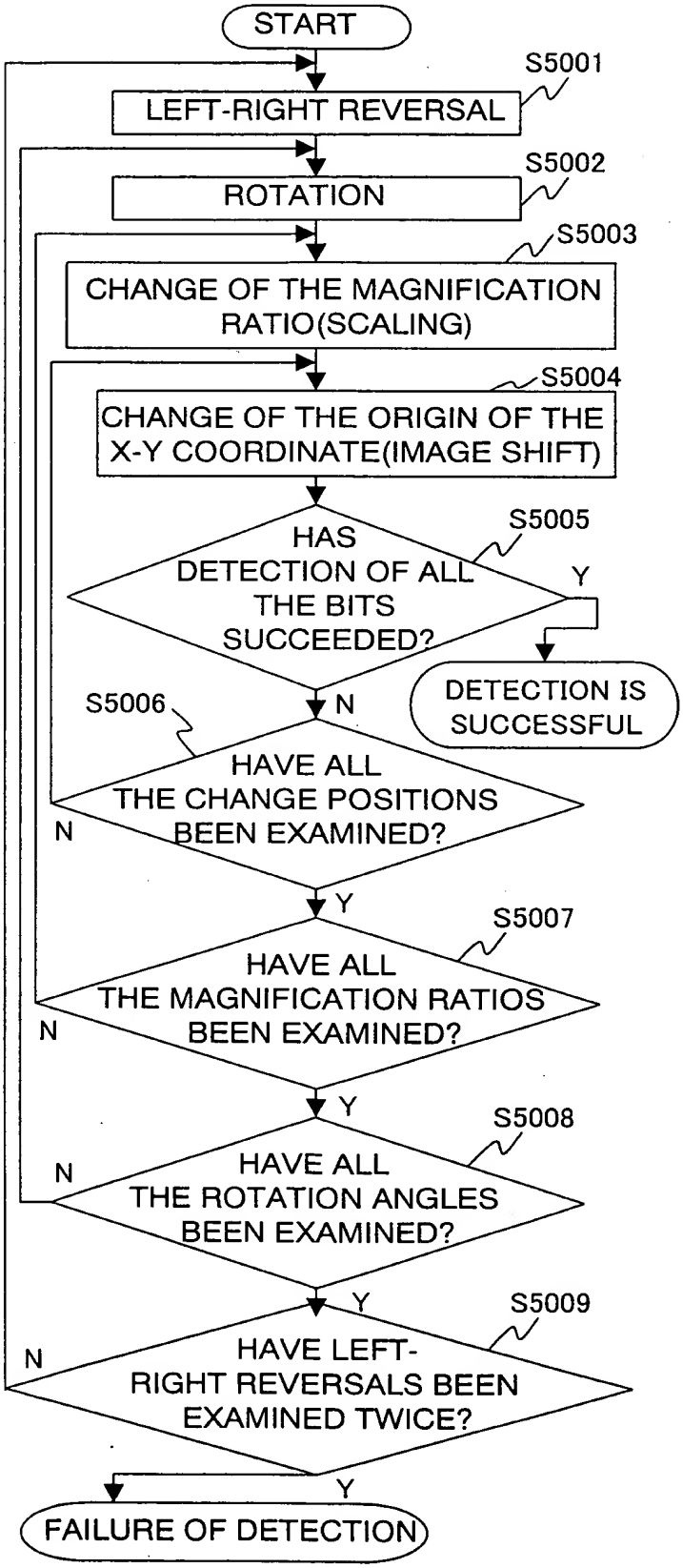


FIG.13B

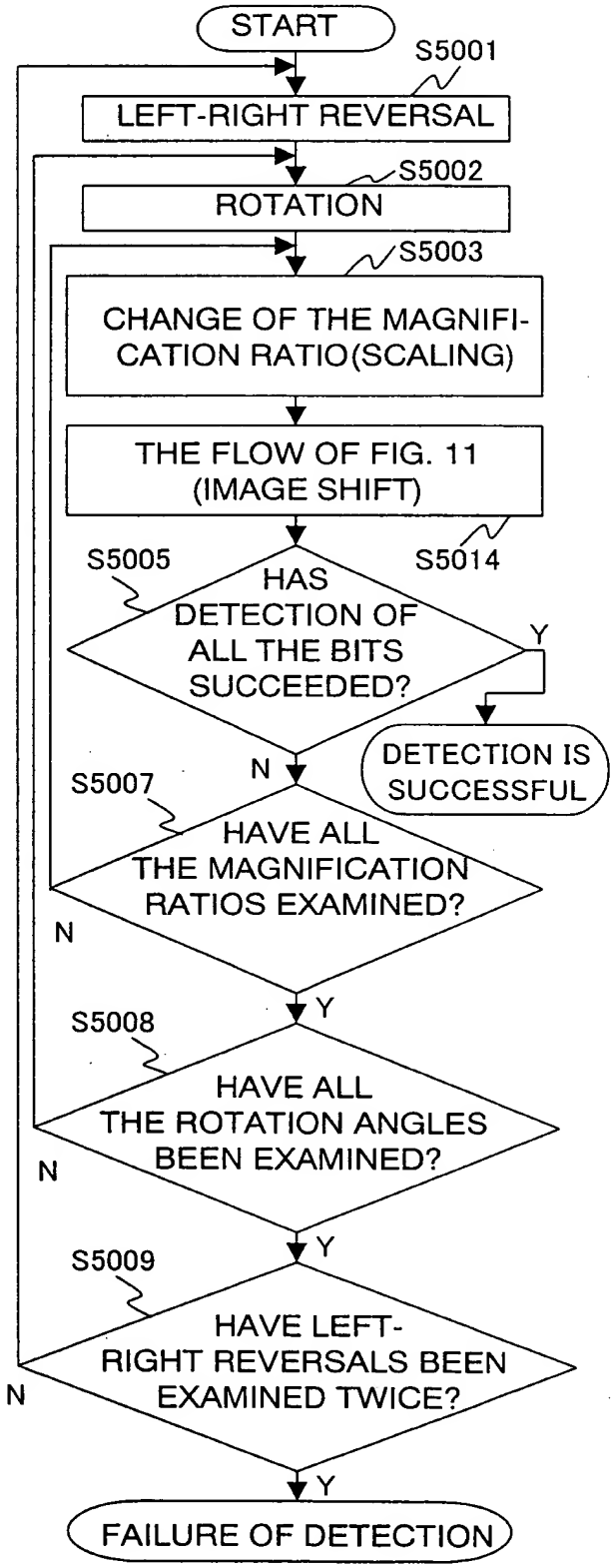


FIG.14

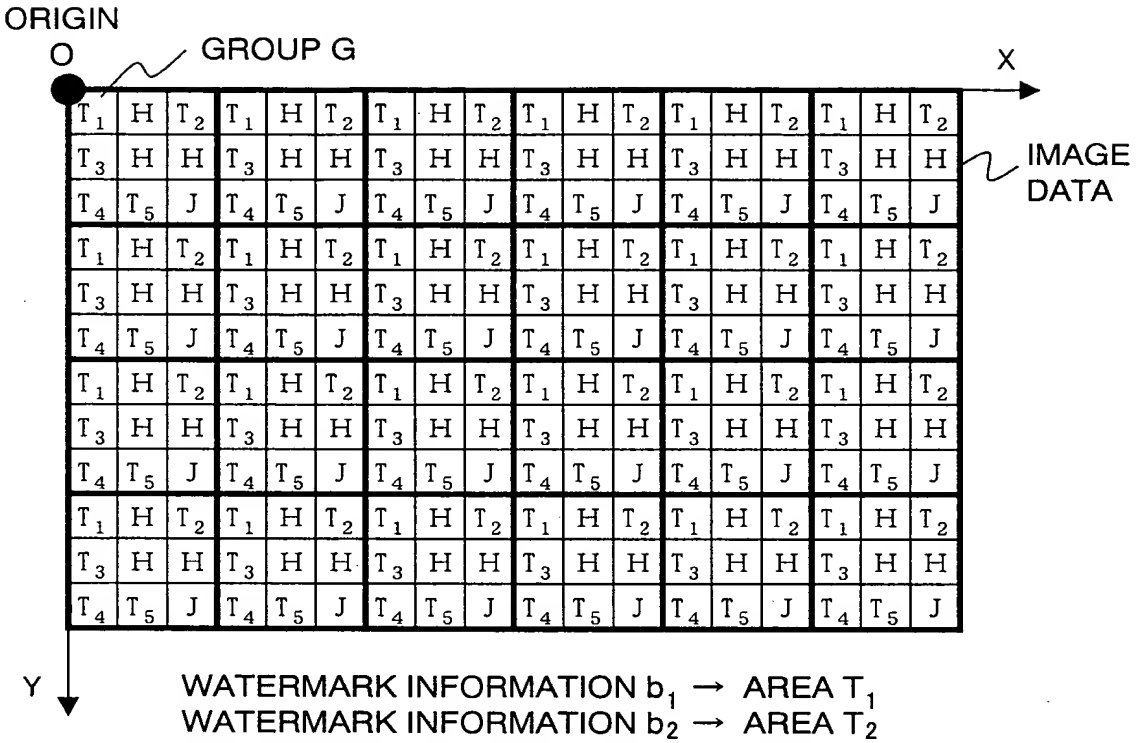

ORIGIN
O
GROUP G
X
Y
IMAGE DATA
WATERMARK INFORMATION b_1 → AREA T_1
WATERMARK INFORMATION b_2 → AREA T_2
WATERMARK INFORMATION b_3 → AREA T_3
WATERMARK INFORMATION b_4 → AREA T_4
WATERMARK INFORMATION b_5 → AREA T_5
WATERMARK INFORMATION b_6 → AREA T_6
WATERMARK INFORMATION b_7 → AREA T_7
EMBEDDING INFORMATION p → AREA J
NO INFORMATION → AREA H

FIG.15

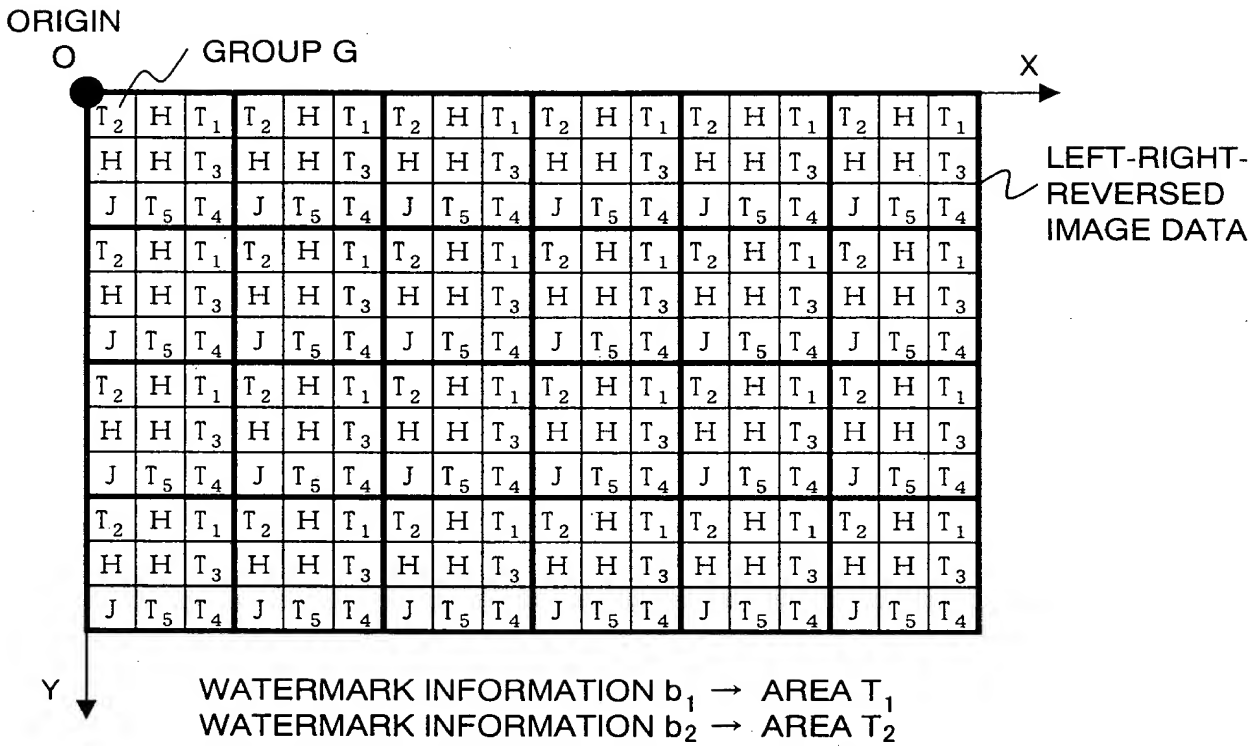

ORIGIN
O
GROUP G
X
Y
LEFT-RIGHT-
REVERSED
IMAGE DATA
WATERMARK INFORMATION b_1 → AREA T_1
WATERMARK INFORMATION b_2 → AREA T_2
WATERMARK INFORMATION b_3 → AREA T_3
WATERMARK INFORMATION b_4 → AREA T_4
WATERMARK INFORMATION b_5 → AREA T_5
WATERMARK INFORMATION b_6 → AREA T_6
WATERMARK INFORMATION b_7 → AREA T_7
EMBEDDING INFORMATION p → AREA J
NO INFORMATION → AREA H

FIG.16

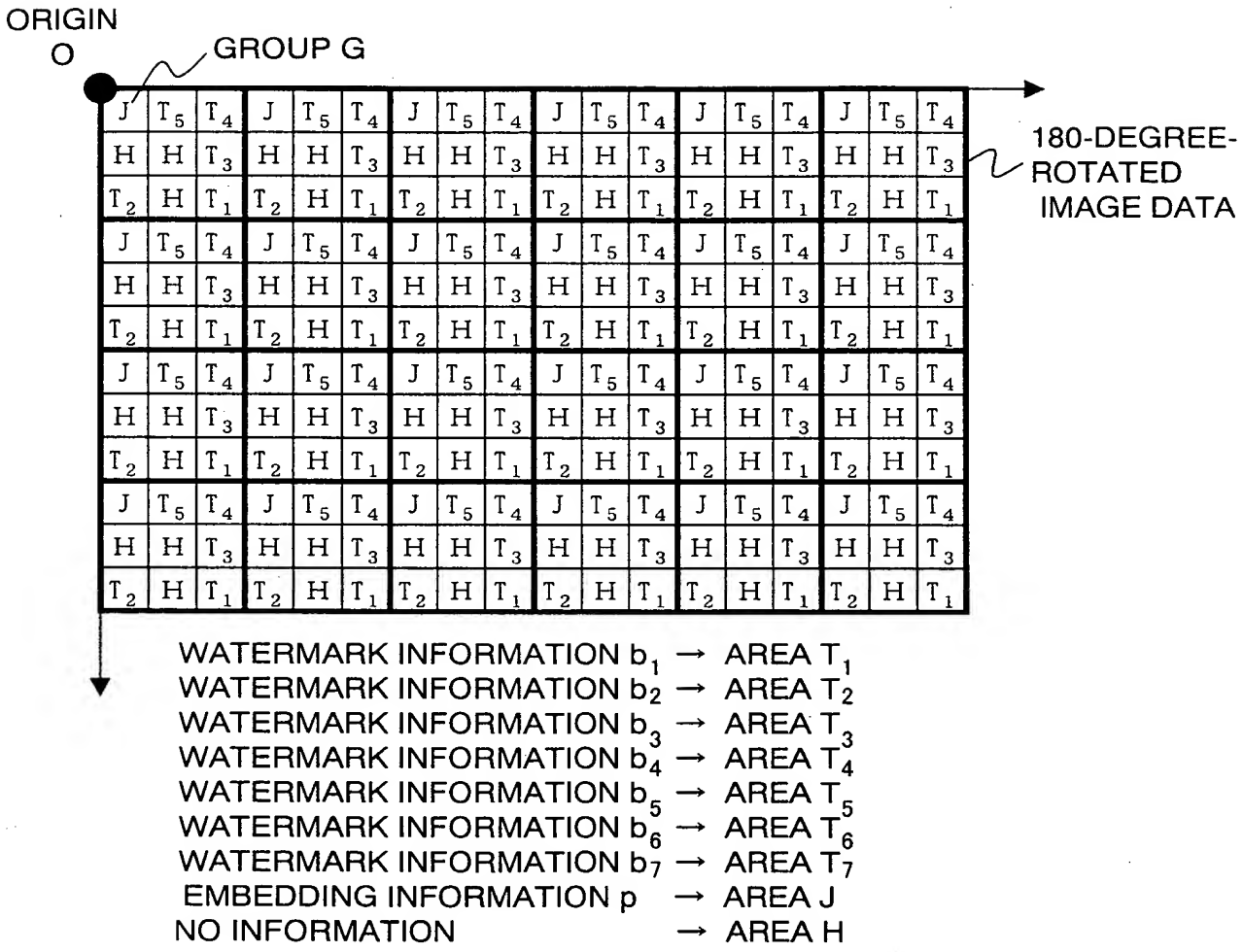
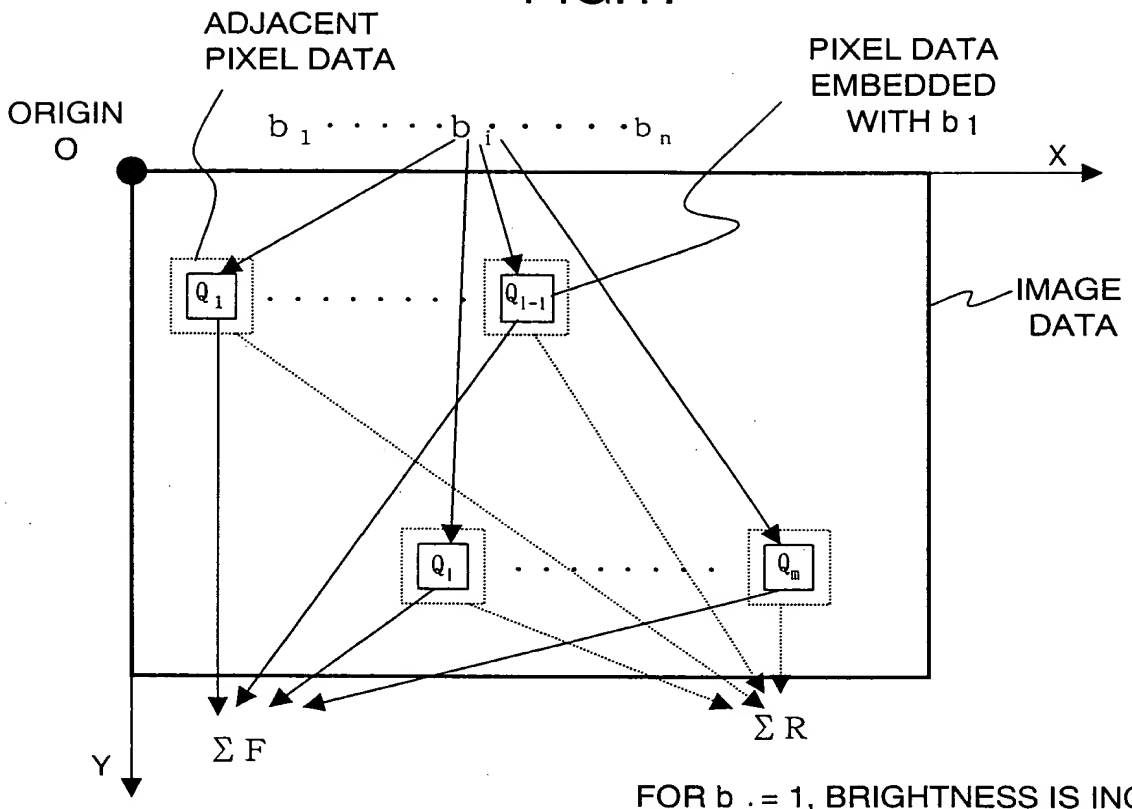

ORIGIN
O
GROUP G
180-DEGREE-ROTATED IMAGE DATA
WATERMARK INFORMATION b_1 → AREA T_1
WATERMARK INFORMATION b_2 → AREA T_2
WATERMARK INFORMATION b_3 → AREA T_3
WATERMARK INFORMATION b_4 → AREA T_4
WATERMARK INFORMATION b_5 → AREA T_5
WATERMARK INFORMATION b_6 → AREA T_6
WATERMARK INFORMATION b_7 → AREA T_7
EMBEDDING INFORMATION p → AREA J
NO INFORMATION → AREA H

FIG.17



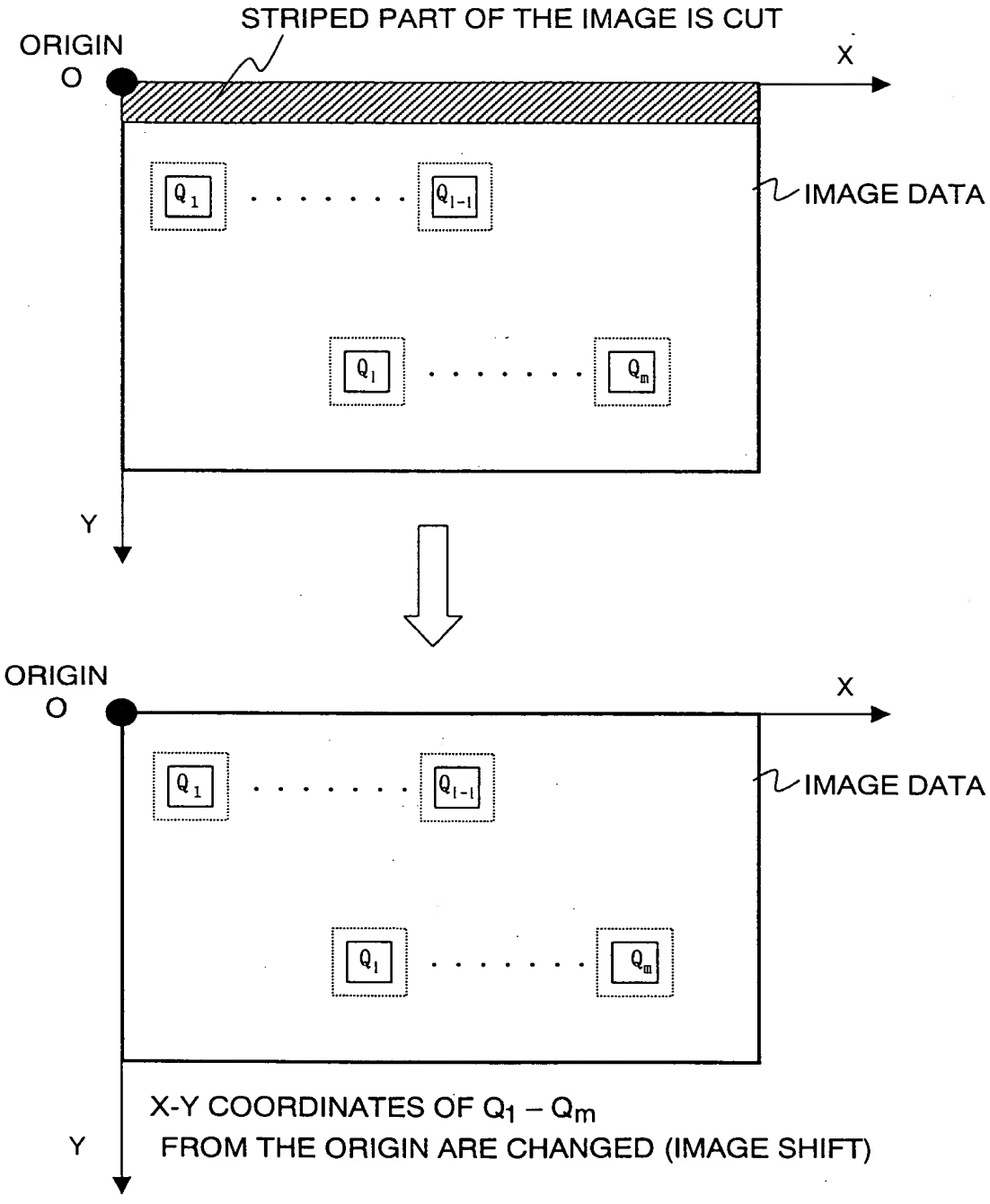
FOR $b_i = 1$, BRIGHTNESS IS INCREASED
FOR $b_i = 0$, BRIGHTNESS IS DECREASED

JUDGEMENT : $\Sigma F - \Sigma R \geqq Th \rightarrow b_{i=1}$

$\Sigma F - \Sigma R \leqq -Th \rightarrow b_i = 0$

$-Th < \Sigma F - \Sigma R < Th \rightarrow$ WATERMARK IS NOT EMBEDDED
(WHERE Th IS A POSITIVE THRESHOLD)

FIG.18


STRIPED PART OF THE IMAGE IS CUT
ORIGIN
O
X
IMAGE DATA
Y
ORIGIN
O
X
IMAGE DATA
Y
X-Y COORDINATES OF Q1 – Qm
FROM THE ORIGIN ARE CHANGED (IMAGE SHIFT)